BARN HAY DRIERS

PART I

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BARN HAY DRIERS
Part I

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INTRODUCTION

In 1939 the U. S. hay crop, of which approximately 42 percent was legumes, ranked No. 2 in value, estimated at $700,000,000. Hay is the most important single feed in production of livestock products and livestock, yet it varies more in quality and feeding value than any other crop. Most dairy and livestock farms could save materially by feeding more high quality hay and less grain per animal unit.

A concerted interest in forced ventilation hay driers originated in the humid southeastern states where it is difficult to cure a high quality hay crop because of uncertain haying weather. Cooperation on this problem between TVA and Tennessee specialists resulted in several practical duct type hay drier designs suitable for the average farm. Interest spread as the number of successful installations increased, and these designs have since been used and modified in other states. As experience accumulates, further advances in hay drying methods can be expected.

I IS MOW CURED HAY BETTER THAN FIELD CURED?

FOR MANY YEARS MUCH WORK HAS BEEN DIRECTED TOWARD IMPROVED yield and nutritive value of forage crops for feed. In the field of agronomy the emphasis has been on plant improvement through selection of breeding and cultural advances through soil improvement, use of fertilizers and improved management. These efforts can be entirely offset by losses during curing, handling and storage of hay crops and this is a common occurrence. While no general survey has been made to determine these losses, the observations of trained men and farm leaders indicate that a 25 percent estimated loss is conservative. These factors, considered together, indicate the importance of hay curing and storage methods which preserve and conserve the hay quality.

Accurate indication of quality as determined by nutritional value requires chemical analysis. However, nutritional content is reflected in a number of physical characteristics upon which U. S. hay standards are based. These are (1) stage of maturity when cut, (2) percentage of leaves, (3) percentage of greencolor, (4) percentage of foreign material, (5) condition as to soundness, (6) coarseness or size of stems, and (7) aroma. Generally speaking, the feeding value of hay is indicated by its physical characteristics. Losses of feeding value of hay cured in the field vary from loss of leaves and green color to loss of the entire crop when haying weather is particularly adverse.

Barn hay curing overcomes to a large extent the principal disadvantage of field curing such as (1) loss of leaves by shattering, (2) danger of damage by rain and dew, (3) loss of quality by bleaching. This method, if proper techniques are used, conserves practically all the original green color and all the leaves of legume hays, which are subject to considerable losses due to shattering in ordinary field curing operations. An indication of the superiority of barn cured hay is shown in the following chart. This is a tabulation of 91 samples of alfalfa taken from farms in Tennessee and Virginia during 1942, 1943, and 1944 where numerous hay drier installations are in operation.

	Percentage of Samples			
	GRADE			
	US No.1	US No. 2	US No. 3	U.S.Sample
Field Cured	9%	26%	35%	30%
Barn Cured	54%	34%	7%	5%

II WHAT ABOUT FIRE HAZARDS?

Mow storage of field cured hay has always been hazardous because of the difficulties in judging when the hay is dry enough to store safely. Barn curing does not present a serious fire hazard because the forced ventilation continually cools the hay until it is cured to a moisture content safe for storage. Actually a hay drier is fire insurance because it provides a means of cooling the hay whenever there is evidence of heating.

III WHAT IS A HAY DRIER?

A hay drier is simply a ventilating system comprised of specially constructed air ducts and a power driven fan. It is designed to blow and distribute evenly large volumes of relatively dry outdoor air through the uncured hay. This air absorbes moisture in moving through the hay and escapes, moisture laden, out of the top of the mow. This type of system can be successfully adapted to the conditions existing in nearly all of the United States. In a very few humid areas the air is heated for satisfactory hay drying. This is a special problem which is not discussed herein. Anyone interested should seek the assistance of specialists in their state.

IV WHAT SHOULD I KNOW TO PLAN AND BUILD A HAY DRIER?

A hay drier is relatively simple to construct and the duct system can be built by anyone inclined toward carpentry. It can be installed in almost any type of building, but to give completely satisfactory results must be designed for the individual hay mow. Any person who wishes to install a hay drier should consult his state college for advice or assistance in designing the duct system and selecting a fan and motor.

There is certain information a college specialist will need to know in order to be of assistance. Some of the important factors are

1 - Amount and kind of hay grown.
2 - Harvesting equipment.
3 - Dimension of mow floor.
4 - Type and condition of floor.
5 - Type of roof.
6 - Height of roof plate above floor.
7 - Mow ventilation.
8 - Location of hay chutes and other obstructions in the mow.
9 - Type of hay handling equipment at the barn.
10 - Availability and voltage of electric service.

11 - Possible locations for fan and motor, considering nearness to electric service, fresh air inlet to fan, and possibility of operating hay hoist.

Further discussion is intended to help interested people understand the factors involved in the design of a hay drier.

Building Requirements

A good roof is essential to dry hay storage. The roof construction affects the operation or design of a hay drier only as it determines the depth of hay storage. Adequate mow ventilation is essential for free escape of moisture-laden air from the top of the hay. An airtight mow floor is important because the air is under pressure as it emerges from the lateral ducts and if cracks exist the air will go downward instead of being forced up through the hay.

Air Requirements

Hay cures to better quality if it is dried quickly. The rate of drying varies in direct proportion to the amount of air blown through the hay. The amount of air required for satisfactory curing is commonly expressed in terms of mow floor area, whereas it actually depends on the volume of hay to be cured. A figure of 10 cubic feet per minute per square foot of mow floor area is accepted as the minimum air volume for long hay piled a uniform depth of eight feet or less. Mow curing trials have indicated that chopped hay and baled hay require more air than long hay. Ohio recommends sixteen cubic feet of air per minute per square foot of mow floor for chopped hay piled eight feet deep. The total air requirements of the mow are determined by multiplying the hay mow storage area times the air

volume figure selected. Example: -- A mow 34 feet by 50 feet has 1700 square feet. (1700x10 /minimum air volume figure/ gives 17,000 cubic feet of air per minute.)

Air flow Resistance

This is the resistance the air ducts and the hay offer to the flow of air. The resistance of hay to a given flow of air varies with the kind of hay, its depth, and whether it is chopped, baled, or long. The air resistance of the air ducts to a given air flow varies principally with the size of the air ducts. However, any factor which creates or affects turbulence in the air flow such as shape of the duct, abrupt bonds, restricted entrances to lateral ducts, and obstructions will affect air resistance. This resistance is expressed in terms of pressure in inches of water. For design purposes, the maximum resistance of a hay drier loaded with eight feet of long hay is commonly estimated at .75 inch water gauge. With 15 to 16 feet of long hay, the resistance pressure would normally be .7 to 1.0 inch water gauge.

Air Distribution

Hay drier design is a problem of providing even distribution of air to the hay, which in turn requires air pressures as uniform as possible throughout the air delivery system. The use of tapered air ducts is a method to obtain this effect. The hay drier plans of various colleges and specialists vary in the design of the air ducts, especially in the extent that the ducts are tapered.

When the total air volume requirements are established, air velocity becomes the determining factor in establishing the size of the main duct. Almost any air velocity lower than the outlet velocity of the fan will be satisfactory. However, there is variance among specialists on this point. In general, low air velocities are desirable because more uniform pressures are possible. But low velocities mean large ducts and higher costs, so design becomes a compromise. TVA and Tennessee specialists design their duct systems for air velocities of 1600 feet per minute. Ohio recommends velocities of 1000 feet per minute or less in the main duct. The entrance to the main duct will have to be at least as large as the fan discharge outlet. The cross sectional area of the main duct just ahead of the first lateral duct is determined by dividing the total air volume required by the mow by the desired air velocity.

Example: Hay mow requires 16,000 cubic feet of air per minute. Desired air velocity is 1600 feet per minute. Cross sectional area of main duct equals 16,000 ÷ 1600 or 10 square feet at the fan end. Dimensions of 3' 4" x 3' would give this area, but the width and height must be large enough to fit the fan discharge openings. Consequently the size of the main duct at the fan is never smaller than the fan discharge opening. It may be larger if desirable.

Lateral ducts are usually spaced 46 to 54 inches on center, depending on the length of the mow. They should run to within six feet from the point nearest the side walls where the hay can be piled to a depth of at least six feet. The TVA Tennessee plan recommends that the entrances to the lateral ducts should be large enough so that the velocity of the air entering the laterals is less than

that in the main duct. This simply means that the laterals should have slightly more total cross sectional area than the main duct. With a tapered main duct, the cross sectional area at any particular point should be approximately equal to the area of the laterals beyond that point. Most plans provide for adjustable inlets to the lateral ducts so that air velocities can be regulated. Air escape openings should be closed at points within four to six feet of posts, hay chutes, or other obstructions on the mow floor.

Type of Design

The type of design to use will depend on the size and arrangement of the buildings and the amount of hay to be handled at one time. If the capacity of the motor must be limited, this becomes a major consideration. Construction of the building may be the determining factor in locating the main duct and placing the fan and motor. The amount of hay to be dried at one time is important, because a depth of at least four feet and not exceeding eight feet for one curing period is desirable. In figuring the tonnage of hay, allow approximately 400 cubic feet to the ton for long hay and 300 to 350 cubic feet per ton of chopped or baled hay. Where chopped or baled hay is to be dried the building should be checked for supporting strength.

There are several general types of duct systems, each of which are adaptations to particular conditions. These systems are (1) center main, (2) side main, (3) divided main, (4) slatted floor. In general, the center main system is suitable when the blowing unit can be located at one end of the barn and the mow width does not exceed 40 feet. The side main system is suitable for mows 30 feet wide and less, or

where it is not convenient to have the main duct in the center of the mow. The divided main system is suited for installations where the ventilating unit cannot be located at the end of the barn. Where the mow is very long and only one half of the mow needs to be utilized for curing at one time, a divided main alternate blowing system can be used which makes it possible to keep the investment in ventilating equipment relatively low. The slatted floor design is more suitable for a side main duct.

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Small Drawings
Showing Various Types

to be
Inserted Here - - -

CONSLUSIONS

I Mow Hay Driers
(a) Are hay crop insurance
(b) Cure hay of superior quality
(c) Reduce hay storage fire hazard

II Design Problems Vary With the Farm and Buildings.

III Learn all you can about this subject and consult your state specialist before installing a Haydrier.

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BARN HAY DRIERS

PART II

(Reviewed by D. W. Teare)

SELECTION OF EQUIPMENT - OPERATION

I How is the Type and Size of Equipment Determined?

II How Should I Operate a Hay Drier?

UNITED STATES DEPARTMENT OF AGRICULTURE
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I How is the Type and Size of Equipment Determined?

Selection of Fans

There are two general classes of fans, axial flow and centrifugal. The propeller fan, an axial flow type, and both forward curve and backward curve multivane blowers, centrifugal types, have suitable operating characteristics for hay drier installations.

Selecting a fan involves consideration of types locally available, cost, limitation on motor capacity, desired fan characteristics and space available for installation. When the choice of fan type is settled, the size with capacity to deliver the volume of air needed against the maximum resistance or static pressure expected is the important determination. Two or three consecutive sizes of a particular type fan may meet the requirements, but one of the sizes will be the most efficient selection for the requirements. All fan manufacturers have available rating tables for their fans. If they are furnished with the basic requirements (air volume needed, resistance pressure range, and maximum size motor allowable) they will select their most efficient fan for the job. These tables are available to any individual who wishes to make his own fan selection. A partial list of fan manufacturers is given below:

Multivane:

American Blower Company	Detroit, Michigan
Bayley Blower Company	Milwaukee, Wisconsin
Buffalo Forge Company	Buffalo, New York
Sturtevant	Boston, Massachusetts

Propeller Type:

Aerovent Fan Company	Piqua, Ohio
TLG Electric Ventilating Co.	2850 North Crawford Avenue Chicago, Illinois
Hartzell Propeller Fan Co.	Piqua, Ohio

Propeller Fan

This fan has curved air foil type blades (similar to airplane propeller) usually six in number. It is light in weight, compact, and reasonable in cost. The power required is almost constant for all ranges of resistance pressure that will be encountered in hay drying. Therefore a fan selected for desired air volume at maximum resistance pressure will never overload the motor seriously even though resistance or static pressure changes considerably. The volume of air this fan will deliver decreases slowly as the static or resistance pressure increases. As it is a high speed fan, it is noisy and should be shielded for safety.

Forward Curve Multivane Blower

This is a slow speed unit in which air velocity is produced by impact. It is particularly suitable where static pressure is constant or nearly so. As static or resistance pressure decreases, it delivers increased quantities of air and requires more power, thereby overloading the motor. This is a dangerous condition which may cause damage to the motor. It is essential that automatic overload controls for the motor be installed with this type fan. This disadvantage can be overcome by varying the speed to suit the conditions or by an adjustable fan discharge damper which can be closed to increase the resistance pressure whenever the air resistance of the hay drier drops. The speed can be changed by having two drive pulleys of different sizes. When this fan is ordered for a hay drier, one or the other of these provisions should be specified. Some manufacturers supply a variable diameter motor pulley to permit regulation of the fan speed. This controls the air volume delivery and

insures maximum air delivery under varying resistance pressure without overloading the motor. An ammeter built into the motor starting box indicates normal loading, overloading and underloading of the motor. The pulley diameter can then be adjusted accordingly to properly load the motor. Operating the motor at rated load under all conditions insures maximum speed of hay drying because the maximum volume of air possible is delivered. This fan is light gauge construction and therefore low cost. It can be obtained in single or double units.

Backward Curve Multivane Blower

This fan operates at relatively high speeds and considerably faster than forward curve blowers of the same size and capacity. It is designed for high efficiencies and quiet, continuous operation necessary in air conditioning. It is not sensitive to changes in resistance pressure and will not overload the motor if pressures change. The major disadvantages of this fan are its weight, cost and size. It is overly well built for the intermittent operation needed by hay driers. The fan is built in single units, but these units are single width or double width.

Electric Motor and Controls

A great majority of the hay driers now installed are electrically powered. The electric motor is reliable and easy to control automatically.

During rainy days and damp nights when air is saturated or nearly so with moisture, it is recommended that the fan be operated just enough to keep the hay from heating. Two devices, the time switch and the humidistat, used separately or together, have given

the most satisfactory automatic control. The time switch is the most reliable device because it is ruggedly built and will operate under almost any condition. The humidistat is a delicate instrument which measures relative humidity and can be used to turn the motor off whenever the relative humidity becomes too high. When placed in the barn and subjected to dust and insects, it usually requires considerable attention.

The motor should be provided with manual or magnetic starting equipment in which overload and low voltage protection is incorporated. When the motor is under automatic control through a time switch or humidistat, magnetic starting equipment must be used.

II HOW SHOULD I OPERATE A HAY DRIER?

Handling Hay in the Field

In the early investigations it became evident that it would be desirable to take advantage of the rapid sun drying in the first few hours after hay is cut. It is generally recommended that the hay be cut in the morning as soon as the dew is off. It is allowed to dry 2 to 3 hours in the swath, then raked into medium sized windrows where it is left for another 2 or 3 hours. On a clear day this amount of field drying will reduce the moisture content to 40 or 50 percent. In order to handle hay with a minimum of leaf shattering, the moisture should be 40 percent or more.

Placing Hay on the Duct System

This is one of the most important steps in mow curing hay. It is extremely necessary to spread the hay evely over the duct system. This should be done as the hay is put in the barn to obtain

proper air distribution through the hay and even curing. Care should be taken to prevent air channels from forming along posts or at the edges of piled hay by packing the hay in these locations. For efficient operation, the hay depth should be four feet or more and should not exceed eight feet. Small amounts of hay can be cured by using a part of the system and blocking movement of air through the unused sections. Batches of greater depth than eight feet can be dried on the system but it will extend the drying period and this is not desirable. After a complete batch of hay has been dried, another layer of any depth desired, but not exceeding eight feet, can be placed on top of the first. The total depth of the settled hay on the system should not exceed 15 or 16 feet.

With chopped hay the first batch should not exceed eight feet in depth, but a six-foot depth would be better. If the system is designed for curing long hay and correspondingly low air volume, the depth of chopped hay should be six feet or less for best results. An additional layer for a later curing can be four to six feet in depth.

Operation of the Fan

The fan should be started as soon as the first hay is put in the barn and operated continuously, except during periods of rain or when the air is excessively damp. For the southeastern states, TVA and Tennessee recommend continuous operation during the day and intermittent operation at night to keep the hay from heating. One hour out of five has been found sufficient for this purpose, and the use of a time switch to turn the fan on for one or more one-hour intervals during the night has been encouraged. In less humid areas,

continuous operation day and night during fair weather shortens the drying period. This is a matter for practical common sense. When the hay is first put in the mow and has high moisture content, drying will take place under more adverse conditions than when the hay is partially dry. Tests on rate of drying have indicated that the hay cures to good quality without moldy or musty spots if dried to 20 percent moisture content in four days and 10 percent in seven days. The important consideration is to reduce the initial moisture content as rapidly as possible. In the latter stages of drying, it is wise to operate the fan under more favorable conditions to avoid adding moisture to the hay.

How to Tell When the Hay is Dry

The time required to dry a batch of hay depends on the type of hay, moisture content when put on the drier, and weather conditions during the drying period. To get the best quality hay, it should be completely dried in seven days.

Since air is forced upward through the hay, the top layer is the last to dry. The heat from the roof will usually dry the top few inches of hay. The operator should inspect the hay at a depth of one to one and one-half feet after five to six days of drying. If the hay at this depth is dry enough to keep, the hay mass is usually safe for storage. However, it is well to run the blower twenty to thirty minutes each day for several days longer and to inspect the hay with the blower running. If warm air is felt rising from any spot in the hay, it is not dry enough and the fan should be operated another day.

CONCLUSION

I High Quality Hay Should be Dried in Seven Days or Less.

II Degree of Success Depends Largely on Careful Hay Storage and Fan Operation.

III Chopped and long Hay Require Different Storage Methods.

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